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Pricing Under the Policy of Guaranteeing the Return of Money in a Two-Channel Supply Chain Using the Game Theory Approach (Case Study: Lorestan Food Industry Company)

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Abstract

Today, one of the topics in supply chain management is "multiple sales channels" and "pricing". In this research, a food producer (West Sahar Dasht Company) has been selected, and several retailers and wholesalers have been considered as the company's customers. Main contribution of this research is, present a pricing model using game theory according to the return of money in the two-channel supply chain. This research dynamically solves the model through the game theory method. To obtain the equilibrium point and Stockelberg, the lower level optimal values (retailers and suppliers) are calculated based on the higher-level values (manufacturer), which turns the multi-level model into a single-level model to calculate the higher level optimal values. By presenting a case study and analyzing the sensitivity of the parameters, it was shown that some changes in the parameters have a significant effect on the problem variables, and its equilibrium model is better. Because game theory is proposed to solve problems on a small scale, and because the present problem is so complex, genetic algorithm meta-heuristic and particle aggregation optimization have been used to solve medium and large problems. To validate their results, they are compared with the results obtained from the mathematical model. Finally, comparing the performance of the two meta-heuristic algorithms through statistical analysis has shown that the particle aggregation optimization algorithm performs better than the genetic algorithm.

Keywords: Two-channel supply chain, Pricing, Money return guarantee policy, Game theory, Meta-heuristic algorithms.

1 | Introduction

The manufacturing industry in its traditional frameworks is facing increasing challenges that are mainly due to poor communication between producer and customer [1], lack of accurate information [2], and lack of appropriate technologies [3]. On the other hand, rapid changes in consumer purchasing behavior and supply chain redesign have led both existing and new retailers to implement a variety of new inventory management strategies [4]. In an unstable business environment accompanied by widespread uncertainty, supply chain managers must determine how to deliver their products and services to customers [5]. Supply chain management involves integrating strategic tools to achieve top management of upstream and downstream processes [6]. The integration of supply, production, and consumption, along with the integration of activities and cooperation between supply chain members, is considered one of the most important supply chain structures [7]. The main

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advantage of the supply chain is the creation of synergy between the supply chain members, which emphasizes increasing competitiveness and reducing costs [8]. On the other hand, supply chain management, by monitoring and controlling unforeseen events and implementing appropriate strategies through a coordinated approach between supply chain members, reduces risk and creates effective risk management throughout the supply chain, especially timely delivery. According to Forbes magazine, companies like Wal-Mart are recognized as the largest companies in terms of sales [9]. The success of these companies is strongly related to the appropriate supply chain operations strategy [10]. Companies that recognize supply chain management as a strategic asset and use it in their day-to-day processes have an average of 70% higher financial performance [11]. Supply chain management includes several core business disciplines, such as accounting, finance, human resources, information systems, and strategy [12]. Proper supply chain management enables companies to optimize purchasing, production, distribution, retail, and even after-sales service by carefully requesting inventory and executing orders and optimizing purchases and production [13]. Many manufacturers have used multichannel distribution systems to gain access to unknown markets and reduce distribution costs [14]. In today's modern and competitive world, managers are looking to establish and implement an efficient and effective supply chain and be accountable for their logistics and support network due to the increasing number of competitors, fierce competition in the market, and reducing costs. The supply chain includes all actions and operations related to the flow and conversion and exchange of goods from the first stage, the raw material to the last stage, delivery to the customer and the end user, and related information flows. Although many companies and factories used only the traditional retail channel to sell and deliver their products, other companies and factories, which understood the development of technology and the emergence of e-commerce and the desire of customers and end user to buy online and offline, decided to use a direct channel to sell their products and services. Therefore, companies must manage and lead end user and consumers in this two-channel structure [15]. Considering that the overall activity of the supply chain has a continuous and complex relationship with the structure and method of supply chain components and its management principles, there is a need for solidarity and coordination at different decision-making levels to achieve better performance and improve conditions. It can be said that the method that can proportionately, in this regard, interpret, analyze, and model the interactions of decisions made in a supply chain against competitors is the game theory approach [16]. Given the above issues, the approach of focusing on distribution channels in the supply chain has led us to do this research. This issue originates from two main areas. On the one hand, researchers' research shows that there is a lack of research in the field of pricing under the policy of guaranteeing the return of money in a two-channel supply chain, and the knowledge gap in this area is clearly visible. Therefore, the present study answers the following basic question.

How is pricing done under the policy of guaranteeing money return in a two-channel supply chain using the game theory approach (case study: Lorestan Food Industry Company)?

To answer the above question, the most important contribution of this research is as follows:

I. Provide a mathematical model based on the game theory for pricing in a two-channel supply chain.
II. Proposed a suitable Nash equilibrium for considered supply chain in small and large scale.
III. Investigated the proposed Model in Stackelberg form and collaboration for two-channel supply chain.

Remaining of the paper organized as follows: in Section 2, prepared a literature review, in Section 3, presented research methodology, in Section 4, presented results and finally in Section 6, presented conclusion and further research.

2 | Literature Review

In this section, the studies are reviewed. For example, Zegordi and Zarouri [17] presented dynamic pricing in a two-channel supply chain with a fixed amount of product in the event of disruption and random demand. In this article, Nash equilibrium game theory is used and cooperative play is introduced

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as a strategy of confrontation or confrontation against disorder. Papi et al. [18] presented a hybrid approach based on decomposition methods and meta-heuristic algorithms to solve the supply chain network design problem. For this purpose, presented an accurate hybrid solution approach based on Banders decomposition method and genetic algorithm. The proposed approach inherits the solution speed from the meta-heuristic and problem-solving algorithms and ensures convergence to the optimal solution from the Banders method. Honarvar et al. [19] presented a pricing model in a two-channel supply chain environment. In the proposed framework considered a competitive consideration of outsourcing policy in conditions of uncertainty. In this research, two models based on continuous and discrete function of expected profit are presented. The discrete model is based on a scenario and is solved using GAMS software and its solution is considered as a continuous model solution. The results show that there are more suitable options for the manufacturer, domestic production and sales than the online channel. Saeed Mohammadi and Kazemi [20] presented a model for coordination in pricing and participation in a supply chain by considering discounts using game theory. In this study, using game theory, two models of the relationship between producer and retailer are considered, including non-cooperative Nash and cooperative play. The bargaining model is proposed to distribute additional joint profits in the cooperative game based on players' risk and bargaining power. The results show that the retail price has the lowest value when the chain components decide to cooperate, while the producer and retailer's advertising costs in the cooperative game have the highest value. Mozaffari and Qashqaei [21] studied a Collaborative pricing and advertising in the two-tier supply chain with a game theory approach. In this paper, used the game theory approach to modeling and solving price variables, economic order, advertising costs of the retailer and manufacturer at the equilibrium point of the game. Results showed that in the collaborative game, the cost of advertising is imposed on the chain relative to the decentralized chain but increases profits and customer satisfaction, which means a win-win decision-making system for managers and consumers of the chain. Modak and Kelle [22] presented a framework for management of a dual supply chain under price and random time-dependent demand. In this paper, examined the dual supply chain under price and demand dependent on delivery time to the customer. Also, presented mathematical models motivated by profit maximization. Finally, analyzed centralized and decentralized systems for the unknown distribution function of random variables and the known distribution function through a free-distribution method. Jabarzare and Rasti-Barzoki [23] presented an approach to game pricing and quality determination through cooperation contracts in a dual supply chain including manufacturer and packaging company. Model in the research considered the content of the strategy under three scenarios: 1) a non-cooperative game, 2) a co-operative game through a revenue-sharing contract, and 3) a co-operative game through a profit-sharing contract. The results show that the competitive game of the manufacturer and packaging company is very beneficial for customers in price search. Pourghader Chobar et al. [24] presented a pricing decision model in a two-channel supply chain using non-stochastic information. In this research, developed and tested a supply chain screening model in which a dominant manufacturer and a retailer operate under asymmetric information. Results show that the manufacturer had to adjust prices -online and offline- based on various factors such as demand uncertainty, market size, and demand sensitivity to price for each channel. Azami and Saidi-Mehrabad [25] presented a bi-level robust optimization model is developed as a leader-follower problem using Stackelberg game in the field of Aggregate Production Planning (APP). The leader company with higher influence intends to produce new products, which can replace the existing products. The follower companies, as rivals, are also seeking more sales, but they do not have the intention and ability to produce such new products. The price of the new products is determined by the presented elasticity relations between the uncertain demand and price. Fassihi et al. [26] presented a Taguchi hybrid method and data envelopment analysis to determine the parameters and operators of meta-heuristic algorithms such as genetic algorithm to solve the problem of re-entry permutation workshop flow. The efficient units are determined and ranked to determine the best algorithm operators according to the objective function in the shortest possible time. Yadegari et al. [27] studied a waste supply chain network design with price-dependent demand. Main results in this paper categorized in two main global trends: 1) economize the collection and recycling of bottles, 2) cost-effective consumption of plastic bottles. Finally, in this research used the learning and teaching optimization algorithm to solve the proposed model. Zhou et al. [28] presented a model for behavior-based price discrimination in a two-channel supply chain with disclosure of retail information. This study explores price-based discrimination strategies of a manufacturer in a two-

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channel supply chain in the presence of retail information disclosure service checks. Liu et al. [29] presented a different study for pricing of products with customer network acceptance in the dual-channel supply chain. In this paper, created the basic demand and profit performance by maximizing the utility for the consumer. Then, used game theory to analyze optimal decisions under single-channel and dual-channel supply chains and examined the impact of different consumer network acceptances on optimal pricing, demand, and supply chain profits. Barman et al. [30] presented an optimal decision making and optimal pricing in a two-channel supply chain. The supply chain model examines maximum profit in both centralized and decentralized decision-making structures. Moreover, the Stalkberg game method has been used to solve the scenarios. According to the numerical findings and sensitivity analysis, the focused scenario is more profitable than the decentralized scenario. Azami and Saidi-Mehrabad [31] presented a seller-buyer model for perishable products under competitive factors. For this purpose, a new demand function is defined considering the price, advertisement, freshness, and encouragement strategies. Finally, a hierarchical heuristic approach is proposed using the genetic algorithm and Benders decomposition algorithm. Azami et al. [32] develops a bi-objective optimization model for the integrated production-distribution planning of perishable goods under uncertainty. The first objective seeks to maximize the profit in a specific supply chain with three levels: plants, distribution centers, and in the last level, customers. Since transportation is one of the major pollution sources in a distribution problem, the second objective is to minimize their emission. In the considered problem, the decisions of production, location, inventory, and transportation are made in an integrated structure.

According to the above mentioned in this study, the combination of Nash and Stockelberg equilibrium game theory has been investigated so that there is a first type of game in the category of suppliers. Suppliers compete with each other to obtain more raw materials from the manufacturer and in the category of retailers. Moreover, the producer is the second type of game that members compete for more profit. Therefore, addressing the issue of pricing in the supply chain and determining the optimal interaction between retailer, manufacturer, and customer is one of the issues that can always be addressed as a good way for supply chain managers.

3 | Research Methodology

In terms of the general approach of this research, it is classified as quantitative due to the use of mathematical models. In terms of inductive-inferential classification, this study falls into the field of inferential studies due to the use of specialization of a general theory in a specific situation and application. In other words, in this research, an attempt is made to use the concept of game theory to create a mathematical model of a two-level competitive supply chain to achieve equilibrium points of the game. In order to collect data, we compile literature and research background from theses available in universities, scientific databases available on the Internet, books, IEEE, and related articles. Especially in this research, a collection of articles published by reputable associations was used. In order to collect data to answer research questions and achieve goals, companies' databases were used, which include the database of production unit (production capacity of machines, amount of orders received), marketing unit (marketing costs, number of wholesalers, and retailers with a history of 5 years or more), accounting unit (sales, revenue, profit, cost of the product) and warehouse unit (inventory, shortage and maintenance costs). The statistical population of this research includes producers, retailers, and wholesalers (customers of producers) in the food industry in Lorestan province in 2019-2020, whose database has been used to price products in the supply chain. To confirm the validity of this study, the Nash and Stockelberg equilibrium models were compared, which showed that the Nash equilibrium model has better performance. In *Fig. 1* depicted proposed conceptual model.

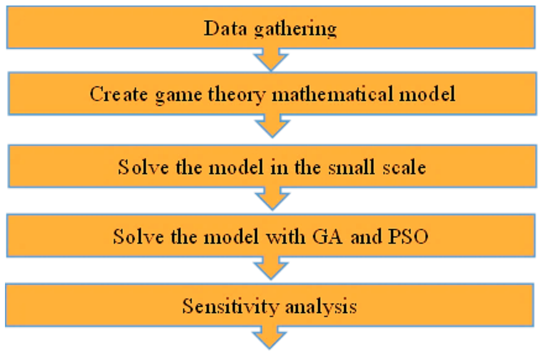

Fig. 1. Conceptual model.

3.1 | Problem Statement

Supply chain structure

In this research, suppose that, there are K retailers in the supply chain that each retailer produces their product from only one manufacturer. In *Fig. 2* shown that the considered supply chain. In general, the consequence of each retailer is the difference between his income and his expenses. In such a situation, the retailer is faced with the costs of ordering, maintenance costs, marketing costs, and a refund for each product. On the other hand, the profit margin of each retailer is the result of the difference between the price paid to the manufacturer for bulk purchase and the selling price to the customer. The variables and parameters used to calculate the retailer outcome are listed and introduced in *Table 1*. It is worth noting that since the final product of each manufacturer is shipped to only one retailer, the number of manufacturers and retailers is equal.

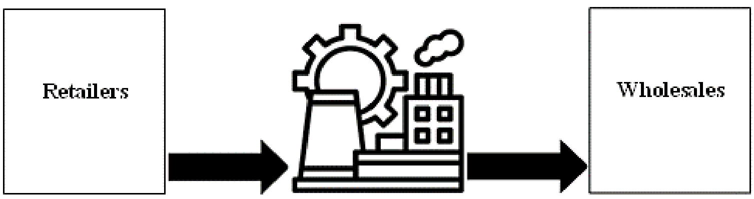

Fig. 2. Supply chcain structure.

Table 1. Symbolism of the general model of retailers.

Number	Symbol	Description
1	G_R	Profit margin of r^{th} retailer
2	P_{rn}	The selling price of the n^{th} product by the r^{th} retailer to the end customer
3	P_n	Bulk selling price of the n^{th} product by the n^{th} manufacturer to the retailer
4	D_n	Demand function of n^{th} product
5	C_m	Marketing costs incurred by the retailer for the n^{th} product
6	k,α,β	Constant demand function, demand price elasticity coefficient and advertising impact factor
7	C_s	Fixed order and purchase costs for the retailer r in each time that the product is purchased
8	Q_r	Order quantity of product n by retailer r
9	K_n	Share of maintenance cost from the purchase price of the product n
10	TR_r	Total revenue of retailer r
11	TMC_r	Total money returns of retailer r
12	TSC_r	Total ordering costs of retailer r
13	THC_r	Total maintenance costs of retailer r
14	TC_r	Total costs of retailer r
15	Z_r	Consequences of retailer r

The general function of each retailer, taking into account demand constraints and sales margins, and if generalized to the entire supply chain, is as follows:

$$\text{Max}Z_1 = (K.P_{rn}^{-\alpha}.C_{mn}^{\beta}[P_{rn} - P_n - C_{mn} - C_{sm}.Q_{rn}^{-1})]) - \frac{1}{2} \times Q_{rn} \times k_n \times P_n,$$

$$\begin{aligned} &\text{s.t.} \\ &P_{rn} - P_n \geq 0, \\ &Dn = K.P_{rn}^{-\alpha}.C_{mn}^{\beta} \geq 0, \\ &Dn \leq PC_n, \\ &k \succ 0, \alpha \succ 1, 0 \prec \beta \prec 1, \alpha - \beta \succ 1. \end{aligned} \quad (1)$$

Develop the profit function of producers

There are N manufacturers in the supply chain that each manufacturer offers its product to only one retailer. On the other hand, the manufacturer receives the materials needed to produce its products from M suppliers active in the supply chain that each raw material can have a different share in meeting the production needs of different products. Each manufacturer earns income from selling the product to the retailer, and on the other hand, it faces different costs for production, supply of raw materials, possible shortages, ordering, and setting up the production line. Therefore, in this section, preparing the outcome of producers active in the supply chain is desired. The variables and parameters used to calculate the manufacturers' outcomes are listed and introduced in *Table 2*. It is worth noting that since the final product of each manufacturer is sent to only one retailer, the number of manufacturers and retailers is equal $(n = r)$.

Table 2. Symbolism of the general model of manufacturers.

Number	Symbol	Description
1	K_s	Consumption coefficient of raw material s in production of n^{th} product
2	C_p	Purchase price of each unit of raw material s
3	C_s	Fixed start-up cost to produce each product n for producer n
4	C_o	Fixed cost of ordering each unit of raw material from supplier s to produce n^{th} product
5	U,Y	Fixed function of production cost per n^{th} product and impact coefficient of scale advantage of gamma
6	C_h	The cost of maintaining each unit of product n
7	B_n	The amount of money returned on the product n for the producer n
8	C_b	Unit cost of shortage for the n^{th} end product and n^{th} manufacturer
9	G_n	Profit margin of the product n and the producer n
10	TR_n	Total income of the producer n
11	TBC_n	Total purchase costs from suppliers for the n^{th} manufacturer
12	TOC_n	Total commissioning and ordering costs for the manufacturer n
13	TPC_n	Total production costs for the producer n
14	THC_n	Total maintenance costs of the end product for the manufacturer n
15	TSC_n	Total cost of product shortages for the producer n
16	PC_n	Production capacity for the producer n

According to the symbolism and items mentioned in the table above, the general model of a manufacturer in the desired supply chain and its constraints is determined in the following model:

$$\begin{aligned} &\text{Max}Z_n = [(P_n - \textstyle\sum_{s=1}^{m}(k_{sn}.C_{pi}) \times D_n] - [\textstyle\sum_{s=1}^{m}(CO_m) + C_{sn}) - [C_{hn} \times \frac{\lambda.Q_{rn} - B_n}{2.\lambda_n.Q_{rn}}] \\ &\times \frac{D_n}{Q_{rn}} - [u.k^{1-y}.P_{rn}^{\alpha.(y-1)}.C_{mn}^{\beta.(y-1)}] - \frac{B_n B_n^2}{2.\lambda_n.Q_{rn}}, \end{aligned}$$

$$\begin{aligned} &\text{s.t.} \\ &P_n - \textstyle\sum_{s=1}^{m}(k_{sn}.C_{pt}) \geq 0, \\ &CP_n \geq D_n, \\ &D_n = k.P_{rn}^{-\alpha}.C_{mn}^{\beta}, \\ &k \succ 0, u \succ 0, \alpha \succ 1, 0 \prec \beta \prec 1, 0 \prec y \prec 1, \alpha - \beta \succ 1. \end{aligned} \quad (2)$$

First period, mass production period: the production period should be consumed because industries have purchased a large volume of fresh raw materials; in other words, industries (producers) do not have the inventory of unused raw materials, and all of them have converted to products.

Second period, production as much as customer demand: in this period, due to the perishability of raw materials, limited supply of fresh raw materials as much as the amount of retail, wholesale orders (customer) for raw material products are purchased, and all manufactured products are sold.

4 | Findings

In this research, a food producer (West Sahar Dasht Company) has been selected, and several retailers and wholesalers have been considered as the company's customers. These customers have a history of more than 5 years of cooperation with the company and in the distribution of the company's products. In the marketing and distribution process, there are 5 products produced by the company and for distribution. This chain's customers (retailers and wholesalers) have the same demand for products, which causes the same price to offer products to wholesale customers and retailers. Since the price of raw materials varies in different periods, to cover the costs of purchase and order, the manufacturer increases the price of products in proportion to the price of raw materials for future periods according to maintenance and production costs. The duration of receiving raw materials in the second period is after the completion of all raw materials in the first period. The producer mass-produces in the first period, and in the second period buys and produces raw materials as much as the retail and wholesale orders. This is due to the perishability of raw materials, reducing waste and storage costs, and responding to orders in different periods.

The products produced are priced by the manufacturer and have a certain quality according to the price. Also, the effect of this quality is reflected in the price of the product. In other words, the higher the price for products, the lower the percentage of unusable products between them. In this chain, the transfer of products takes place through the routing of means of transportation. In other words, there is a set of means of transportation with specific costs and capacities that are selected to send products in each period. In each period, the transportation vehicles that serve each customer (retailer and wholesaler) are determined. They started their journey from the manufacturer and referred to the assigned customers to deliver the requests and receive the returns. Then, they travel to the collection center to deliver the returns, and again at the end of the route, they return to the producer. Also, the money for the wasted products is returned to the retailers and wholesalers. In each period, one to a maximum of v transport vehicles can be used, and none of them can load more than their capacity along the way. In this issue, we seek to determine the price of products, order raw materials, determine the location of the collection center and select and determine the route of transportation; in such a way that the profits of retailers, wholesalers, and producers are maximized.

4.1 | Model in Nash Equilibrium

4.1.1 | Production of sample problem on a small scale

To evaluate the performance of the model presented in this section, a sample problem is determined and examined. The sample problem was implemented in Lingo software. The sample supply chain problem presented in this section includes (FL_l) 10 customers, 3 potential locations for the construction of the collection and dismantling center. The construction costs in each location are 670000, 860000, and 700000, respectively. The number of vehicles is 2, the capacity of each vehicle (CV_l) is 170,000 and 150,000, respectively. There are three types of raw materials whose volumetric coefficient (W_r) is 2, 1 and 1, respectively, and the rate of materials that can be used after disassembly (Q_r) is 0.71 and 0.74, respectively. The number of products is equal to 2 and their volume coefficient (W_m) is 9 and 6, respectively. This is an example for 2 planning periods. Also, the coefficient of consumption of raw materials in product 1 is 1, 1 and 3, respectively, and in product 2 is equal to 3, 1 and 3, respectively.

By implementing the presented problem to minimize costs, the result of the model is obtained after spending 12 minutes. The minimum total cost of the chain is equal to 70822706 Rials—the costs of ordering, purchasing, maintenance, using vehicles, routing vehicles, and construction of the collection and disposal center for spoiled food is equal to 2243500, 65569810, 1200726, 490000, 648670 and 670000, respectively. Location 1 has been selected to construct a collection center for the collection and disposal of spoiled food. In the first period, both vehicles of transportation were used. The first vehicle traveled from the manufacturer to customers 9, 6, 5, 7, 10, respectively. After traveling to the collection and disposal center of spoiled food, it returned to the manufacturer. Customers 2, 8, 3, 4, and 1 are served by the second vehicle during the same period, respectively. In the second period, only the second vehicle of transportation is used. After serving the customers, 8, 2, 9, 6, 5, 7, 10, 1, 3, and 4, this vehicle travels to the collection and disposal center, and finally, it returns to the producer.

4.1.2 | Validation of meta-heuristic algorithms

The average relative deviation percentage index for examined algorithms is calculated as follows:

$$\mathrm{RPD} = \frac{(\mathrm{Alg\,sol}) - \mathrm{Bestsol}}{\mathrm{MinBest}} \times 100, \tag{3}$$

and is the best value calculated for each experiment by all the proposed algorithms. The exact method is used to validate genetic and particle swarm optimization algorithms and compare them. For this purpose, in the above, the value of $\mathrm{Best}_{\mathrm{sol}}$ is equal to the result obtained from the exact method. The results of this comparison for the presented sample show that the percentage of relative deviation of the genetic algorithm and particle swarm optimization algorithm is very small. In this example, the exact solution method has obtained the optimal amount of profit equal to 70822706 Rials, and the value obtained for the profit function using GA and PSO algorithms are equal to 70817748 Rials and 70819873 Rials, respectively, which have RPD equal to 0.007 and 0.004, respectively. The value of less than one percent of PRD indicates the proper performance of these two algorithms.

4.1.3 | Numerical examples

The parameters in these problems are generated randomly at specified intervals. The nodes for the sample problems are also randomly generated in a square space with a side of 200 units distance, and the $\mathrm{DIST}_{\mathrm{IJ}}$ (distance between them) is calculated based on the step distance. The efficiency of meta-heuristic algorithms is directly related to setting its parameters, so that choosing the correct values of the parameters of an algorithm increases its efficiency. In this research, the control factors of Taguchi method include the parameters of genetic algorithm and particle swarm optimization algorithm. In this method, the aim is to find the optimal levels of important controllable factors and minimize the effect of perturbation factors. Qualitative characteristics measured from the experiments are converted to signal (S / N) ratio. This rate indicates the amount of deviations displayed in the response variable. The reduction of algorithm deviations is when the genetic algorithm parameters are set at 125 for the initial population, 130 for the number of generations, 0.95 for the intersection rate and 0.50 for the mutation rate, respectively. Also, the parameters of the particle swarm optimization algorithm are equal to 100 for the number of particles, 115 for repetition, 0.8 for the weight of inertia and 0.2 for the maximum speed, respectively, which are the best values for the proposed algorithm in this research. *Table 3* shows the levels of each parameter.

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Table 3. Levels of each main parameters of the problem.

Levels	Parameters
50,30,15,10	The number of customers
5,3,2	The number of products
15,10,5	The number of potential locations
4,3	The number of vehicles
7,5,3	The number of time periods

Table 4 shows the results of the proposed algorithms. Computational time and RPD indices are used to compare the performance of each algorithm. According to *Table 4*, the average error of the genetic algorithm and particle swarm optimization algorithm equals 0.0128 and 0.0451, respectively, which indicates the PSO algorithm's better performance than the GA algorithm.

Table 4. Computational results from the comparison of (GA; PSO) and Exact method.

Problem	The Number of Products	The Number of Periods	The Number of Customers	The Number of Potential Locations	The Number of Vehicles	RPD	CPU Time	RPD	CPU Time	RPD	CPU Time
1	2	3	12	5	3	0.001	71	0.0062	56	0.0004	42
2	3	3	15	5	3	0.0076	90	0.003	67	0.0001	56
3	5	3	30	5	3	0.0435	136	0.0249	98	0.0000	78
4	2	5	50	5	3	0.0156	365	0.0088	275	0.0006	150
5	3	5	70	5	3	0.0629	653	0.0046	546	0.0003	330
6	5	5	100	5	3	0.0854	1057	0.0004	777	0.0004	650
7	2	7	10	5	3	0.0636	203	0.0114	148	-	-
8	3	7	15	5	3	0.0795	245	0.0274	179	-	-
9	5	7	30	5	3	0.0818	384	0.0196	282	-	-
10	2	3	50	5	3	0.00095	279	0.0009	229	-	-
11	3	3	70	10	3	0.0069	451	0.0001	329	-	-
12	5	3	100	10	3	0.022	460	0.0043	339	-	-
13	2	5	10	5	3	0.0396	136	0.0018	101	-	-
14	3	5	15	10	3	0.0612	180	0.0047	123	-	-
15	5	5	30	10	3	0.043	290	0.0099	230	-	-
16	2	7	50	10	4	0.0192	986	0.0488	740	-	-
17	3	7	70	10	4	0.0668	1607	0.0159	1187	-	-
18	5	7	100	10	4	0.0837	2672	0.0123	1999	-	-
19	2	3	15	5	4	0.0038	97	0.001	73	-	-
20	3	3	15	10	4	0.0151	100	0.0118	77	-	-
21	5	3	30	15	4	0.0109	202	0.0032	198	-	-
22	2	5	50	15	4	0.0647	613	0.0078	464	-	-
23	3	5	70	15	4	0.0974	978	0.0175	726	-	-
24	5	5	100	15	4	0.0673	1601	0.0205	1193	-	-
25	2	7	10	15	4	0.0085	305	0.0307	188	-	-
26	3	7	15	15	4	0.0996	300	0.015	226	-	-
27	5	7	30	15	4	0.0513	480	0.035	359	-	-
28	2	3	50	15	4	0.0029	239	0.0007	215	-	-
29	3	5	70	15	4	0.0443	992	0.0063	742	-	-
30	5	7	100	15	4	0.0946	2896	0.0317	2139	-	-
Mean						0.0451		0.0128		0.0018	

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4.2 | Model in Stackelberg form and Collaboration

4.2.1 | Game theory based on competitive / non-competitive discussion in the manufacturer-distributor supply chain

Competition between producer and distributor

In this method, all the producers play in pairs with the distributor. In other words, in each game, two producers and one distributor compete with each other. Profit ratio as the matrix data of the pairwise comparisons of the two producers is given as input to the model, and after solving it, the producers are weighted in terms of profit in the supply chain. These comparisons are made based on three decision criteria separately.

I. Based on the producer's profit: In this comparison, the producer's profit ratio for a two-player game is considered as the result of a pairwise comparison in the comparison matrix.

II. Based on customer satisfaction: In this comparison, the customer satisfaction ratio for a two-player game is considered as the result of a pair comparison in the comparison matrix. Customer satisfaction is calculated from the following formulation for each participant.

$$W_1\left({}^{P_i}\!/\!{}_{P_j}\right)+W_1\left({}^{S_i}\!/\!{}_{S_j}\right)+1, \tag{4}$$

where w1 is the weight of the price for the customer and w2 is the weight of the service for the customer.

III. Based on the distributor's profit: In this comparison, the ratio of profit that is distributed to the distributor from each producer is considered for a two-player game as a result of a pair comparison in the comparison matrix.

Results of producers' pair game with customers (wholesalers and retailers)

Table 5 presents a case study of supply chain pricing in dynamic mode.

Table 5. Product data.

Products	Service Cost Coefficient	Production Cost	Market	Price Unit (Rial)		Service Levels	Sensitivity of the Market			
				Wholesaler	Retailer		Differences of Services	Services	Differences of Prices	Price Unit (Rial)
tomato sauce	1200	2000	4200	2800	4500	15	4	5	6	8
canned beans	1400	2800	5800	4000	5000	15	4	5	6	8
canned apple	1600	1750	6000	2400	4300	10	4	5	6	8
pickle	1200	2180	4700	3000	6000	6	4	5	6	8
cucumber	2000	1800	4500	2670	4600	15	4	5	6	8

The level of service in this game is quality. Because after the price, quality has the highest rank. That is, producing a quality product is a competitive advantage.

Optimal game-based outputs defined in the case study

Table 6. Wholesale price of the first participant of Stackelberg producer (prices are in Rials).

Products	Tomato Sauce	Canned Beans	Canned Apple	Pickle	Cucumber
tomato sauce	3239,886	3342,806	3353,092	3303,665	3243,082
canned beans	3775,75	3878,665	3888,945	3839,531	3778,98
canned apple	3830,113	3933,044	3943,325	3893,904	3833,346
pickle	3571,628	3674,563	3684,846	3635,422	3574,853
cucumber	3255,232	3358,1	3368,379	3318,986	3258,445

Table 7. Retail price of the first participant of Stackelberg producer (prices are in Rials).

Products	Tomato Sauce	Canned Beans	Canned Apple	Pickle	Cucumber
tomato sauce	2620,821	2672,295	2677,4	2652,745	2622,49
Canned beans	2789,122	2840,573	2845,671	2821,028	2790,805
canned apple	2791,526	2842,991	2848,09	2823,441	2793,211
Pickle	2836,84	2888,309	2893,411	2868,759	2838,518
Cucumber	2528,208	2579,614	2584,712	2560,087	2529,875

Tables 6 and *7* show wholesale and retail prices of the first participant of Stockelberg producer. Each of them shows how the wholesale and retail prices are compared to each other, and in different pricing conditions, how has it been able to attract market traction?

Table 8. Level of service of the first participant of Stackelberg wholesale (prices are in Rials).

Products	Tomato Sauce	Canned Beans	Canned Apple	Pickle	Cucumber
tomato sauce	6,199332	6,714031	6,765462	6,518325	6,215408
Canned beans	8,232291	8,661104	8,703937	8,498046	8,24575
canned apple	9,455061	9,922926	9,969658	9,745017	9,469753
Pickle	7,007753	7,49792	7,546888	7,311535	7,023109
Cucumber	4,547599	4,869063	4,901185	4,746832	4,557641

Table 9. Service level of the first participant of Stackelberg retail (prices are in Rials).

Products	Tomato Sauce	Canned Beans	Canned Apple	Pickle	Cucumber
tomato sauce	6,208214	6,722365	6,773996	6,527446	6,224903
Canned beans	8,246682	8,67122	8,713927	8,508567	8,256708
canned apple	9,468951	9,936624	9,982639	9,758553	9,483732
Pickle	7,01753	7,507605	7,556293	7,32151	7,033502
Cucumber	4,551219	4,872366	4,904449	4,750544	4,561717

Tables 8 and *9* show the service level of the first participant in Stackelberg wholesalers and retailers. Each of them shows the service level of the first participant in comparison with each other and in different service level conditions; how has it been able to pull the market?

Table 10. Wholesale price of the first participant for the producer Stackelberg (prices are in Rials).

Products	Tomato Sauce	Canned Beans	Canned Apple	Pickle	Cucumber
tomato sauce	4247,258	4576,688	4616,565	4400,801	4300,966
Canned beans	5238,195	5567,58	5607,45	5391,709	5291,911
canned apple	5356,121	5685,529	5725,401	5509,649	5409,839
Pickle	4729,418	5058,836	5098,71	4882,953	4783,131
Cucumber	4389,726	4719,047	4758,913	4543,202	4443,432

Table 11. Retail price of the first participant for the producer Stackelberg (prices are in Rials).

Products	tomato Sauce	Canned Beans	canned Apple	Pickle	Cucumber
tomato sauce	4245,821	4575,085	4614,906	4399,275	4299,593
Canned beans	5236,336	5565,573	5605,388	5389,771	5290,122
canned apple	5354,022	5683,274	5723,09	5507,466	5407,809
Pickle	4727,81	5057,068	5096,886	4881,259	4781,591
Cucumber	4388,607	4717,794	4757,608	4542,015	4442,375

Tables 10 and *11* show the retail price of the first participant for the manufacturer Stackelberg. Each of the numbers shows how the retail prices of the first participant are compared to each other, and in different price conditions, how has it been able to pull the market.

Table 12. Wholescale profit of producer Stackelberg (prices are in Rials).

Products	Tomato Sauce	Canned Beans	Canned Apple	Pickle	Cucumber
tomato sauce	9973032	11697796	15243666	12545842	10036661
Canned beans	25332658	28040522	12698896	12622321	23651147
canned apple	28075500	30215333	16214723	16452133	26541233
Pickle	14051198	75123655	18321456	18200142	27651884
Cucumber	13748500	86662175	21003647	17698227	29654133

Table 13. Retail profit of producer Stackelberg (prices are in Rials).

Products	Tomato Sauce	Canned Beans	Canned Apple	Pickle	Cucumber
tomato sauce	42316622	56412330	853211572	145336415	50182364
Canned beans	36251123	54321566	814236990	162013366	65421369
canned apple	35621422	57148330	891452300	175431146	65795133
Pickle	33154210	55124788	751489963	146521333	69230145
Cucumber	36214501	52145698	652314778	132564822	706821369

Tables 12 and *13* show the wholesaler and retailer profit of the producer Stackelberg. Each of the numbers shows how the producer profit is compared to each other, and in different conditions, how have the retailer and wholesaler been able to influence the company?

Table 14. Wholesale profit from Stackelberg producer (prices are in Rials).

Products	Tomato Sauce	Canned Beans	Canned Apple	Pickle	Cucumber
tomato sauce	81256453	84512698	145987230	4895317532	458796213
Canned beans	82146977	54786138	465231785	659822133	458752156
canned apple	26541333	226793314	326541230	451236640	452330214
Pickle	48765231	154793138	123658463	154796211	495621479
Cucumber	54786231	157433999	479923156	985611456	512365987

Table 15. Retail profit from Stackelberg producer (prices are in Rials).

Products	Tomato Sauce	Canned Beans	Canned Apple	Pickle	Cucumber
tomato sauce	65321233	26542300	32654230	45621300	51420321
Canned beans	12542336	28752320	33652144	45627336	56230025
canned apple	15423625	29874123	26214523	49533170	55621352
Pickle	12032654	26543210	12336852	46985032	56587423
Cucumber	14502658	21542398	15987533	47533392	52652239

Tables 14 and *15* indicate wholesale and retail profits for the producer Stackelberg, each of which shows how the wholesale profits in different products are compared to each other and in different profit conditions, how has the retailer been able to influence the company?

Table 16. Wholesale demand of Stackelberg manufacturer (source: research finding).

Products	Tomato Sauce	Canned Beans	Canned Apple	Pickle	Cucumber
tomato sauce	236533301	32102665	654230014	321662300	87542300
Canned beans	125542660	62354236	689523001	362654233	45875126
canned apple	126535595	52314580	985632104	351479257	45169986
Pickle	132652021	56125874	653216622	265325899	56324556
Cucumber	165423017	59321458	587423001	215632866	61182699

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Table 17. Retail demand of Stackelberg manufacturer.

Products	Tomato Sauce	Canned Beans	Canned Apple	Pickle	Cucumber
tomato sauce	8070,678	8070,678	8070,678	8070,678	8070,678
Canned beans	1236,326	9563,156	10326,215	9881,216	1288,266
canned apple	1265,654	8451,125	1023,156	9564,123	1123,123
Pickle	1452,698	6542,145	1068,145	9133,541	1060,14
Cucumber	1065,699	1021,654	1022,478	9205,123	1065,584

Tables 16 and *17* indicate wholesale and retail demand for the manufacturer Stackelberg. Each of them shows how the wholesale and retail demands for different products are compared to each other and in different situations; how have different wholesale and retail demands been able to influence the company?

Table 18. Customer satisfaction level comparison matrix - Stackelberg wholesaler and manufacturer.

Products	Tomato Sauce	Canned Beans	Canned Apple	Pickle	Cucumber
tomato sauce	1	0.63256	0.865323	1.03656	1.412365
Canned beans	0.68851	1	10326,215	0.638465	0.638542
canned apple	0.94324	1.063572	1	1.542366	0.68335
Pickle	1.25536	1.255442	0.638461	1	0.638461
Cucumber	0.68851	1.545907	0.940228	1.063572	1

Table 19. Customer satisfaction level comparison matrix - Stackelberg retailer and manufacturer.

Products	Tomato Sauce	Canned Beans	Canned Apple	Pickle	Cucumber
tomato sauce	1	0.638461	0.68851	0.895507	1.545907
Canned beans	0.68851	0.895507	0.829484	0.68851	0.895507
canned apple	0.68851	0.638461	1	1.545907	0.68851
Pickle	0.68851	0.829484	0.638461	1	0.638461
Cucumber	1.102851	0.68851	0.940228	1.063572	1

Tables 18 and *19* show the level of customer satisfaction for the manufacturer Stackelberg according to the demand of wholesalers and retailers. Each of them shows the level of customer satisfaction compared to each other, and in different conditions, how can customer satisfaction affect the company?

5.3 | Sensitivity analysis

Analysis of the producer's profit sensitivity to change a1

First, the changes in producer profits relative to changes in the market base for products are examined. The chart of changes indicates that an increase in the basis of the producer market will lead to an increase in profits for the producer. This increase for the producer whose market base has increased will increase his profit much more than the wholesale and retail profit for the producer, so the increase in profit for the producer is due to the increase in the number of customers who shift from wholesalers and retailers to producers due to price and service sensitivities, which in turn increases the producer's profits. This chart can be used to show the profit changes, to calculate the economic level a1 of each manufacturer in order to overcome the competitor. This decision can be very successful at the managerial level because each manufacturer, assuming the competitive market level is stable and by increasing the size of their market or increasing the level of advertising, can achieve the economic level of their market base. This level is important because over-advertising is as costly as it is profitable.

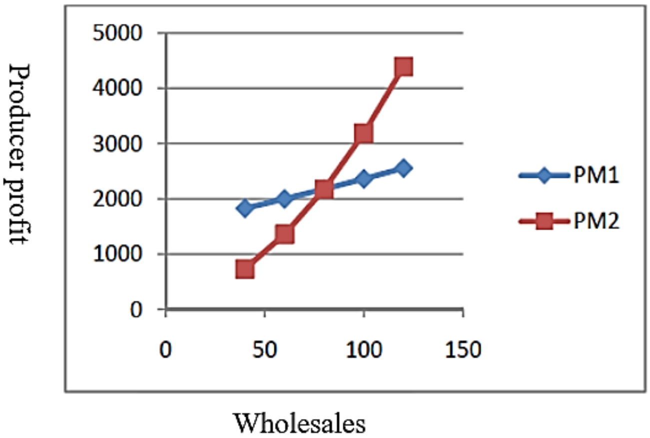

Fig. 3. Analysis of sensitivity of producer profit to a1 change in wholesale Stackelberg.

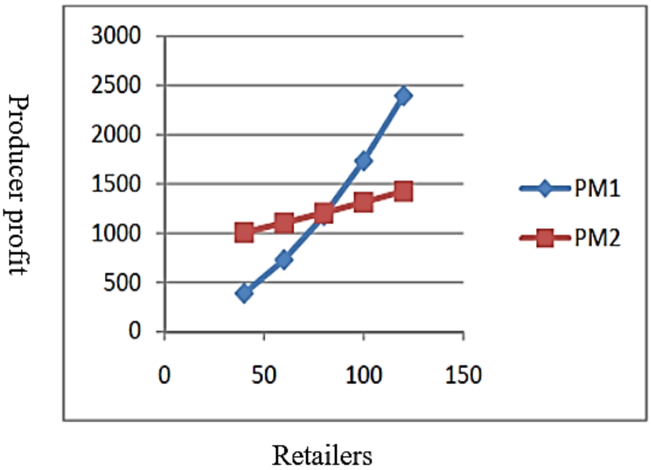

Fig. 4. Analysis of sensitivity of producer profit to a1 change in retail Stackelberg.

Analysis of the producer's profit sensitivity to c1 change

For example, the graph of the change in producer profit by the change in production costs for producers is examined. The change graph shows that a reduction in the cost of production leads to an increase in profits for the producer, while the profits of wholesalers and retailers decrease at the same time. This change is much bigger for a producer whose production cost is reduced than for another producer. Also, it is not far-fetched to increase the profit for each producer by decreasing c. The decrease in profit for the next producer is due to the increase in the number of customers who turn from their customer set to the desired manufacturer because of the price sensitivity and services (the reduction in the wholesale price of the producer whose costs are reduced), which in turn increases the producer's profit.

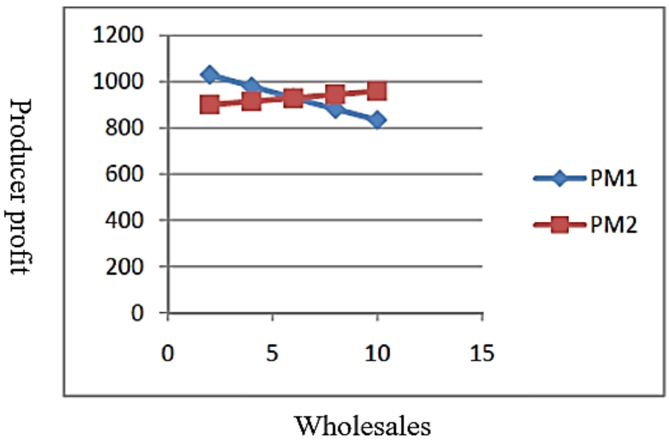

Fig. 5. Analysis of producer profit sensitivity to c1 change in wholesale Stackelberg.

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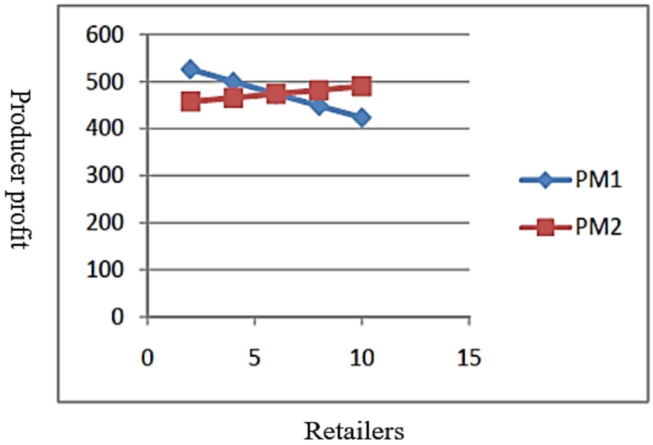

Fig. 6. Analysis of producer profit sensitivity to c1 change in retailer Stackelberg.

Analysis of the distributor's profit sensitivity to change a1

The distributor's profit, like the profit of the producer, increases with the increase of the market base. Increasing the market base will also increase the distributor's profit from cooperating with manufacturers. This increase in profits occurs in two different ways.

I. Increasing profit to increase the retail price: Although wholesale price increases due to increasing market base and consequently increasing demand, the distributor with a higher ratio can increase retail prices due to an increase in service level to balance the game. As a result, the value of the expression pi-wi increases.
II. Increasing profits to increase sales volume: Certainly, increasing the market base affects the number of sales. Distributor profits are also an ascending function of sales volume.

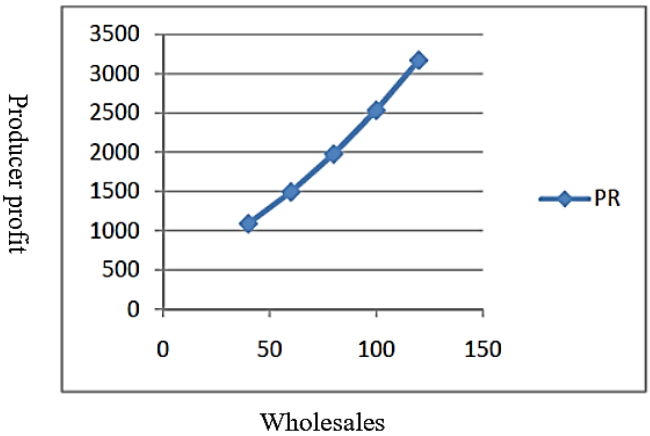

Fig. 7. Analysis of producer profit sensitivity to a1 change in wholesale Stackelberg.

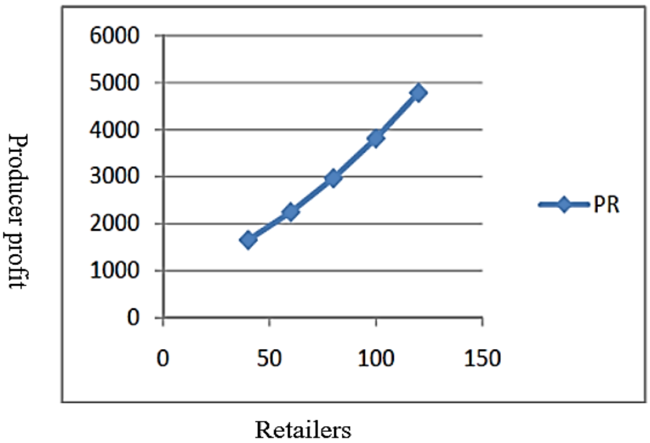

Fig. 8. Analysis of producer profit sensitivity to a1 change in retail Stackelberg.

Analysis of wholesale and retail profits sensitivity to change c1

Certainly, the distributor's profit increases as a result of reduced production costs due to a reduction in wholesale costs. Therefore, in order to maintain its position from the distributor's point of view and improve its competitive position, the manufacturer should seek to reduce production costs. This process can further contribute to the manufacturer's competitive advantage by increasing the market base because the profit for another producer decreases and further improves the producer's competitive position. The decline in other producers' profits is also due to a reduction in demand because the manufacturer attracts more competitor demands by reducing the wholesale price and retail price.

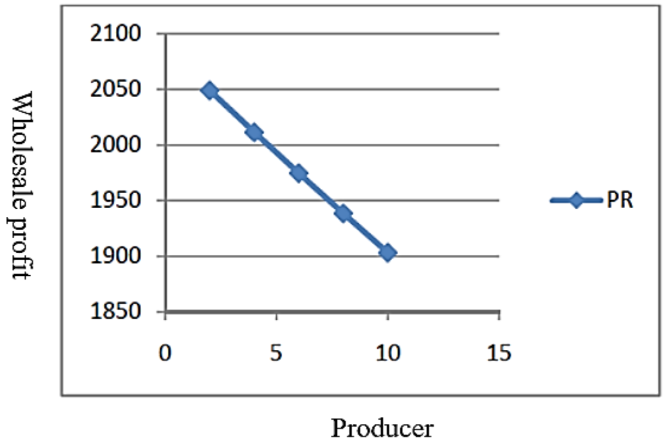

Fig. 9. Analysis of wholesale profit sensitivity to c1 change in producer Stackelberg.

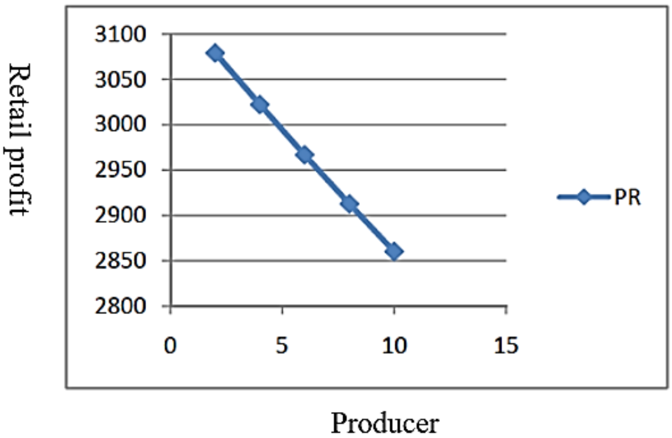

Fig. 10. Analysis of retail profit sensitivity to c1 change in producer Stackelberg.

6 | Conclusion

Given that price fluctuations are high in the Iranian economy, it seems that the pricing modeling of money return guarantee policy and its comparison with static pricing will persuade companies to increase competition by applying pricing money return policy models. Therefore, this paper examines a two-channel supply chain, including several retailers, one manufacturer, and several suppliers. The competition takes place in all three categories of this supply chain, and the manufacturer produces different products and offers to retailers. Competition between chain members is shown in two forms: horizontal competition and vertical competition. Competition and coordination modeling on pricing strategy is presented under a mathematical model. Also, in this model, the relations between the supply chain members in the game are considered cooperative. This model assumes that the producer has more power and imposes its decisions on suppliers and retailers. In other words, the producer has the role of leader, and other members have the role of follower. Finally, sensitivity analysis is performed on the most important parameter of the model, which first introduces problem-solving algorithms. In market structure studies, the horizontal structure for a product is mainly evaluated. While non-competitive

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behavior is not necessarily related to horizontal behavior, the horizontal structure represents only a part of market power. In fact, market power is the result of a combination of horizontal and vertical competition at different levels of the market. The horizontal structure of the product market is far from competitive, and manufacturers can raise the price of these products above the final cost of production. This means that if there is competition between suppliers or retailers in comparison or other suppliers and retailers, the competition is vertical; otherwise, the competition is horizontal if the retailer or wholesaler does not pay attention to the price of other competitors. Given the complexity of supply chain problems, the proposed problem cannot be solved in a reasonable time for real-world dimensions. Therefore, the meta-heuristic approach in the form of genetic algorithms and particle swarm optimization has been used to solve it. This research is classified in terms of general approach due to the use of mathematical models of quantitative type. In terms of inductive-inferential categorization, this study falls into the field of inferential studies due to the use of specialization of a general theory in a specific situation and application. In other words, in this research, an attempt is made to use the concept of game theory to present a mathematical model of a two-level competitive supply chain and then achieve equilibrium points of the game. In this research, a food producer (West Sahar Dasht Company) has been selected, and several retailers and wholesalers have been considered as the company's customers. These customers have a history of more than 5 years of cooperation with the company and in the distribution of the company's products. In the marketing and distribution process, there are 5 products produced by the company and for distribution. This chain's customers (retailers and wholesalers) have the same demand for products, which causes the same price to offer products to wholesaler and retailer customers. This research was examined in two parts of Nash and Stackelberg equilibrium. The initial model showed that the supply chain pricing capability in Stackelberg mode is suitable with two genetic algorithms and particles. Then the proposed problem is solved by the game theory and dynamic method. It is discussed that in order to obtain the equilibrium point of Stackelberg, the lower level optimal values (retailers and suppliers) are calculated based on the higher-level values (manufacturer), which turns the multi-level model into a single-level model to calculate the higher level optimal values. By presenting a case study and analyzing the sensitivity of the parameters, it is shown that some changes in the parameters have a significant effect on the problem variables, and so the Nash equilibrium model is better. The results of this research can be extended to other industries. The main limitation of this research is the use of recorded data. To overcome the large amount of data, the resulting data is used for one year, which causes an acceptable amount of data to be lost. Also, this research has been done on manufacturers, retailers and wholesalers. Therefore, it does not have the ability to generalize to all components of the supply chain. For this purpose, it is suggested to use collusion games such as Nash-Cornot for further research. Finally, most important managerial insight of the research is as follows:

I. The proposed framework is able to provide a systematic approach to strategic decisions.
II. Predict the outcome of competitive conditions and identify optimal strategic decisions.

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References

[1] Feng, L. (2020). Current situation and upgrade of the management mode of aviation. Manufacturing supply Chain. *Journal of Shanxi university of finance and economics*, *42*(S2), 10-14.

[2] Pattanayak, D., & Punyatoya, P. (2020). Effect of supply chain technology internalization and e-procurement on supply chain performance. *Business process management journal*, *26*(6), 1425-1442.

[3] Maadanpour Safari, F., Etebari, F., & Pourghader Chobar, A. (2021). Modelling and optimization of a tri-objective transportation-location-routing problem considering route reliability: using MOGWO, MOPSO, MOWCA and NSGA-II. *Journal of optimization in industrial engineering*, *14*(2), 83-98.

[4] Zhang, J., Onal, S., & Das, S. (2017). Price differentiated channel switching in a fixed period fast fashion supply chain. *International journal of production economics*, *193*, 31-39.

[5] Chiang, C. T., Kou, T. C., & Koo, T. L. (2021). A systematic literature review of the IT-based supply chain management system: towards a sustainable supply chain management model. *Sustainability*, *13*(5), 2547. https://www.mdpi.com/2071-1050/13/5/2547

[6] Wong, W., Husain, R., & Sulaiman, A. (2018). Managing upstream and downstream relationships in supply chain for military organisation. *International journal of business and management*, *2*(1), 72-77.

[7] Song, G., & Song, S. (2020). Fostering supply chain integration in omnichannel retailing through human resource factors: empirical study in China's market. *International journal of logistics research and applications*, *24*(1), 1-22. DOI: 10.1080/13675567.2020.1713305

[8] Paula, I. C. D., Campos, E. A. R. D., Pagani, R. N., Guarnieri, P., & Kaviani, M. A. (2020). Are collaboration and trust sources for innovation in the reverse logistics? Insights from a systematic literature review. *Supply chain management: an international journal*, *25*(2), 176-222.

[9] Forbes. (2014). *Wal-Mart Stores*. https://www.forbes.com/companies/walmart/?sh=52c615bfb03d

[10] Bogenrief, M. (2012). *Three things that kmart needs to fix IfIt wants to survive*. https://www.businessinsider.com/is-it-blue-lights-out-for-kmart-2012-1

[11] Kozlenkova, I. V., Hult, G. T. M., Lund, D. J., Mena, J. A., & Kekec, P. (2015). The role of marketing channels in supply chain management. *Journal of retailing*, *91*(4), 586-609.

[12] Hult, M. T., Closs, D., & Frayer, D. (2013), *Global supply chain management: leveraging processes, measurements, and tools for strategic corporate advantage.* McGraw Hill.

[13] Chaudhuri, A., Dukovska-Popovska, I., Subramanian, N., Chan, H. K., & Bai, R. (2018). Decision-making in cold chain logistics using data analytics: a literature review. *The international journal of logistics management*, *29*(3), 839-861.

[14] Rangaswamy, A., & Van Bruggen, G. H. (2005). Opportunities and challenges in multichannel marketing: an introduction to the special issue. *Journal of interactive marketing*, *19*(2), 5-11.

[15] Karimaabadi, K. (2016). *Determining the optimal pricing policy and reproduction rate in a two-channel supply chain* (Master Thesis, kharazmi University). https://elmnet.ir/article/10935095-19691/

[16] Maleki, Sh. (2015). *Risk assessment in two-channel supply chain pricing model with game theory approach* (Master Thesis, Payame Noor University of Tehran). https://elmnet.ir/Article/10860495-4268/

[17] Zegordi, S. H., & Zarouri, F. (2018). Dynamic pricing in a two-channel supply chain with a fixed amount of product in the event of random disruption and demand, *Industrial engineering and sharif management*, *34.1*(2.2), 31-42. (**In Persian**). https://doi.org/10.24200/j65.2018.20082

[18] Papi, A., Barzinpour, F., & Pishvaei, S. (2020). A hybrid approach based on parsing methods and meta-heuristic algorithms to solve the supply chain network design problem. *Operations research in its applications*, *17*(4), 63-88. (**In Persian**). https://jamlu.liau.ac.ir/article-1-1880-fa.pdf

[19] Honarvar, M., Rezaei H., & Keshavarz, T, Y. (2016). Presenting the pricing model in the competitive two-channel supply chain considering the outsourcing policy in conditions of uncertainty. *13th international conference on industrial engineering*, Mazandaran University of Science and Technology, Babolsar International Hotel. (**In Persian**). https://www.sid.ir/paper/881329/fa

[20] Saeed Mohammadi, Z., & Kazemi, A. (2017). Presenting a model for coordination in pricing and cooperation in a supply chain with consideration of discount using game theory. *International Journal of industrial engineering and production management*, *1*(28), 101-117. (**In Persian**). http://www.iust.ac.ir/ijiefa/article-1-1236-fa.pdf

[21] Mozaffari, M., & Qashqaei, H. (2017), Collaborative pricing and advertising in a two-tier supply chain with a game theory approach. *Tomorrow management scientific research journal*, *18*, 191-202.

[22] Modak, N. M., & Kelle, P. (2019). Managing a dual-channel supply chain under price and delivery-time dependent stochastic demand. *European journal of operational research*, *272*(1), 147-161.

[23] Jabarzare, N., & Rasti-Barzoki, M. (2020). A game theoretic approach for pricing and determining quality level through coordination contracts in a dual-channel supply chain including manufacturer and packaging company. *International journal of production economics*, *221*, 107480. https://doi.org/10.1016/j.ijpe.2019.09.001

[24] Pourghader Chobar, A., Adibi, M. A., & Kazemi, A. (2021). A novel multi-objective model for hub location problem considering dynamic demand and environmental issues. *Journal of industrial engineering and management studies*, *8*(1), 1-31.

[25] Aazami, A., & Saidi-Mehrabad, M. (2019). Benders decomposition algorithm for robust aggregate production planning considering pricing decisions in competitive environment: a case study. *Scientia Iranica*, *26*(5), 3007-3031.

[26] Fassihi, M., Najafi, S. I., Tavakoli Moghadam, R., & Haji Aghaei Keshtali. M. (2021). Taguchi combined method and data envelopment analysis to determine the parameters and operators of meta-heuristic algorithms - genetic algorithm to solve the problem of re-input permutation workshop flow. *Operations research in its applications*, *18*(2), 107-124.

[27] Yadegari, E., Alam Tabriz, A., Zandieh, M., Salahi, F., & Daneshvar, A. (2021), Designing a pet supply chain network with price-dependent demand: the meta-heuristic algorithm is adapted to the display method. *Recent research in decision making*, *6*(1), 171-199.

[28] Zhou, J., Zhao, R., & Wang, B. (2020). Behavior-based price discrimination in a dual-channel supply chain with retailer's information disclosure. *Electronic commerce research and applications*, *39*, 100916. https://doi.org/10.1016/j.elerap.2019.100916

[29] Liu, W., Qin, D., Shen, N., Zhang, J., Jin, M., Xie, N., Chen, J., & Chang, X. (2020). Optimal pricing for a multi-echelon closed loop supply chain with different power structures and product dual differences. *Journal of cleaner production*, *257*, 120281. https://www.x-mol.net/paper/article/1224456158424616960

[30] Barman, A., Das, R., & De, P. K. (2021). An analysis of optimal pricing strategy and inventory scheduling policy for a non-instantaneous deteriorating item in a two-layer supply chain. *Applied intelligence*, 1-25. https://link.springer.com/article/10.1007/s10489-021-02646-2

[31] Aazami, A., & Saidi-Mehrabad, M. (2021). A production and distribution planning of perishable products with a fixed lifetime under vertical competition in the seller-buyer systems: a real-world application. *Journal of manufacturing systems*, *58*, 223-247. https://doi.org/10.1016/j.jmsy.2020.12.001

[32] Aazami, A., Saidi-Mehrabad, M., & Seyed-Hosseini, S. M. (2021). A bi-objective robust optimization model for an integrated production-distribution problem of perishable goods with demand improvement strategies: a case study. *International journal of engineering*, *34*(7), 1766-1777.